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RESOURCES

ABILITY, EXPERIENCE, AND TASK DIFFICULTY
PREDICTORS OF TASK PERFORMANCE

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Training Systems

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Ability, Experience, and Task
Difficulty Predictors of Task
Performance

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SUMMARY

This work investigated main effects and interactions among aptitude, job and task experience, and task difficulty in predicting AFS 426x2, Jet Engine Mechanic, task performance. Aptitude (as measured by the Armed Services Vocational Aptitude Battery Mechanical Aptitude Index), job and task experience composites, and task learning difficulty indices (LDIs) were all found to be significant predictors of task performance. Contrary to expectations, task difficulty did not consistently affect relationships of task performance to either aptitude or experience. However, small but statistically significant interactions between aptitude and experience were found, indicating that task performance becomes less predictable from aptitude scores over a mechanic's first term of enlistment. Finally, one approach to determining aptitude requirements from indices of situational demands (LDIs) was illustrated. Future research should (a) investigate the usefulness of other person and situational predictors of task proficiency, (b) improve the definition and measurement of job experience, (c) investigate changes in performance determinants over time, (d) attempt to statistically separate true score effects on proficiency measures from those due to measurement bias, and (e) extend these analyses to other Air Force Specialties.

PREFACE

The research described in this paper was completed while the first author was under appointment as a Summer Research Fellow at AFHRL/IDE, Brooks Air Force Base, Texas. The research was conducted as part of a Joint-Service Job Performance Measurement/Enlistment Standards Project to develop prototype measures of job performance and link enlistment standards to on-the-job performance. The first author thanks Universal Energy Systems, the Air Force Office of Scientific Research, and the AFHRL staff for supporting this research.

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ABILITY, EXPERIENCE, AND TASK DIFFICULTY
PREDICTORS OF TASK PERFORMANCE

I. INTRODUCTION

Three metatheoretical approaches guide current research in industrial/organizational psychology (Terborg, 1981). A situational approach (Bowers, 1973; Epstein & O'Brien, 1985) seeks to explain human behavior (performance) in terms of differences in situational characteristics (e.g., Komaki, Zlotnick, & Jensen, 1986; Oldham, Hackman, & Pearce, 1976); intrasituational variability in behavior is regarded as experimental error.

A trait approach seeks to explain behavior in terms of stable, latent individual difference variables (Schmidt, Hunter, & Pearlman, 1981; Stagner, 1977) and attributes cross-situational variability in behavior to statistical artifacts, measurement inadequacies, and random fluctuations in behavior.

An interactional approach (Ekehammer, 1974; Endler & Magnusson, 1976; Epstein & O'Brien, 1985) assumes that both situational characteristics and stable individual differences determine behavior (e.g., James & White, 1983; Kozlowski & Hults, 1986). Both intrasituational and cross-situational variability in behavior represent "to-be-explained" sources of variance.

The general lack of research on person-situation interactional determinants of job performance (O'Connor, Eulberg, Peters, & Watson, 1984; Schneider, 1978; Terborg, Richardson, & Pritchard, 1980) and practical concerns of the Air Force motivated this study of predictors of Jet Engine Mechanic (AFS 426x2) task performance.

Research Objectives

Four questions motivated the research described below: (a) To what extent do situational variables (task learning difficulty, Weeks, 1984) and person variables (job/task experience and task-relevant aptitudes) predict task performance? (b) Does task learning difficulty and/or job or task experience interact with task-relevant aptitudes in predicting performance? (c) To what extent do alternative measures of task proficiency capture comparable aspects of the total criterion space (Kavanagh, Borman, Hedge, & Gould, 1986)? (d) Is it feasible to establish differential aptitude requirements based on the analysis of situational demands?

II. PREDICTORS OF TASK PERFORMANCE

Task-Relevant Aptitudes

Meta-analyses of validity studies suggest that cognitive ability tests are consistent predictors of job performance (e.g.,

Hunter & Hunter, 1984; Pearlman, Schmidt, & Hunter, 1980; Schmidt, Hunter, & Caplan, 1981). Armed Services Vocational Aptitude Battery (ASVAB) scores are used in selection and classification decisions by the military (Vineberg & Joyner, 1983), and the validity of ASVAB composites in predicting training success criteria is well documented (e.g., Mullins, Earles, & Ree, 1981). ASVAB aptitude indices (AIs), of which there are four (Mechanical, Administrative, General, and Electronics), are relatively global predictors and should thus be more highly related to global, rather than to specific, job proficiency measures (Fishbein & Ajzen, 1974). However, it was also hypothesized that:

H1: A significant and positive relation existed between the ASVAB Mechanical Aptitude Index and Jet Engine Mechanic task performance.

Task Difficulty

The task difficulty concept is found in literature relating to goal setting (e.g., Locke, Shaw, Saari, & Latham, 1981), perceived job characteristics (e.g., Stone & Gueutal, 1985), task taxonomies (e.g., Fleishman, 1978), and human factors research on workload (e.g., Moray, 1982). Task difficulty has been defined and measured in terms of characteristics intrinsic to the task (e.g., production standards, Locke et al., 1981) and the task performer (e.g., physiological measures such as pulse rate variability; Casali & Wierwille, 1983; Wierwille, Rahimi, & Casali, 1985). Difficulty measures also range from relatively objective (e.g., normative task difficulty, Terborg, 1977) to quite subjective indices (e.g., self ratings of subjective workload, Moray, 1982).

Burtch, Lipscomb and Wissman (1982), Fugill (1973) and Weeks (1984) defined task difficulty in terms of "time required for a typical employee to learn to perform a task satisfactorily." Task Learning Difficulty Indices (LDIs) are derived from ratings of tasks by Subject Matter Experts (SMEs) and are ultimately linked to ASVAB aptitude areas (Burtch et al., 1982). Thus, this approach operationalizes task difficulty in terms of subjective ratings of a characteristic of the task performer and focuses on the tasks' cognitive demands.

Some approaches to defining task difficulty predict a positive relation between difficulty and performance. Goal setting literature supports the notion that higher production goals lead to increased productivity (Locke et al., 1981), and literature relating to perceived job characteristics suggests that employee perceptions of challenging and autonomous work environments are associated with higher levels of job performance and satisfaction (Loher, Noe, Moeller & Fitzgerald, 1985; Stone & Gueutal, 1985). However, an inverse relation is generally proposed (Fleishman, 1978; McGrath, 1976; Moray, 1982; Weeks, 1984). It was also hypothesized that:

H2: An inverse relation existed between task learning difficulty and task performance.

There is also rationale for a nonlinear relationship between task difficulty and task-relevant aptitudes in predicting task performance. Terborg (1977), for instance, suggested that ceiling and floor effects on extremely easy and extremely difficult tasks would limit the predictability of performance from aptitudes to tasks of intermediate difficulty. Since no tasks in the present study were considered extremely difficult, it was hypothesized that:

H3: Increasingly stronger positive relationships between task-relevant aptitude and task performance would be found on tasks of increasingly higher learning difficulty.

Job and Task Experience

It is commonly assumed that greater job-related experience leads to more effective job performance. This assumption may partly underlie the larger salaries afforded the more experienced workers (Medoff & Abraham, 1980, 1981) and the prior experience requirements for entry into many jobs.

Work experience is correlated with, and generally confounded with, age (Mathews & Cobb, 1974; Rhodes, 1983; Schwab & Heneman, 1977; Waldman & Avolio, 1986). Experience has been indexed by group-level aggregate measures (e.g., Horowitz & Sherman, 1980) and individual measures of career stage (e.g., Katz, 1978), organizational tenure (e.g., Maier & Hiatt, 1985), position tenure (e.g., Gininger, Dispenzieri, & Eisenberg, 1983; Kozlowski & Hults, 1986), and the number of times a task has been performed (e.g. Spiker, Harper, & Hayes, 1985).

There is evidence for an inverse (e.g., Rothe, 1949), zero (e.g., Cobb, 1968), positive (e.g., Gininger et al., 1983; Maier & Hiatt, 1985) and curvilinear relationship (Mathews & Cobb, 1974; Spiker et al., 1985) between experience and job performance. Cobb (1968) suggested that negative correlations between experience and performance at extremely long lengths of tenure may be attributable to aging effects, and Brown (1982) suggested that beneficial effects of additional experience may be observed only in samples of relatively short mean lengths of tenure. Since the participants in this research were all first-term airmen, it was hypothesized that:

H4a: Job experience, indexed by organizational tenure ,and

H4b: Task experience would both relate positively to task performance.

Since the conceptual specificity of task experience corresponds closely with criteria used in this effort, we expected task experience to be a better predictor of task performance than job experience.

Literature also suggests that experience and aptitudes may interact in predicting task performance (Maier & Hiatt, 1985). It was hypothesized that:

H5: Weaker positive relations between task-relevant aptitudes and task performance would exist with greater levels of experience.

Other Interactions

Fugill's (1973) definition of task difficulty suggests:

H6: Increasingly stronger positive relations should be found between experience and performance on tasks of increasing learning difficulty.

Maier and Hiatt (1985) also alluded to the possibility of a three-way interaction between task difficulty, experience, and aptitudes in predicting task performance. We hypothesized:

H7: (a) for low difficulty tasks, a positive relation between task experience and task performance for lower aptitude but not for higher aptitude airmen; (b) for moderately difficult tasks, linear and additive experience and aptitude effects in predicting task performance; and (c) for high difficulty tasks, a positive relation between aptitude and performance for higher aptitude but not for lower aptitude airmen.

III. METHOD

Data were collected in the spring of 1985, through the Walk-Through Performance Testing (WTPT) methodology (Hedge, 1984) and by paper-and-pencil measures. Job performance and related measures were collected on 255 Jet Engine Mechanics (AFS 426x2). Data collection procedures and the complete Jet Engine Mechanic Job Performance Measurement Data Base are described in detail elsewhere (Hedge & Teachout, 1986).

Measures

The following measures were adapted from the Jet Engine Mechanic Job Performance Measurement Data Base for the present research:

Performance Measures

WTPT Scores. Tasks in the Air Force Specialty (AFS) 426x2 WTPT were each composed of several performance steps. Tasks varied in the number of component steps, and steps within tasks varied in their criticality. The WTPT scores reported here were 10-point weighted step scores that (a) reflect the relative criticality of task steps, and (b) express task scores on a comparable 10-point metric.

Overall Performance Ratings (OPRs). These proficiency ratings were completed by WTPT administrators immediately after an airman completed a WTPT task. The 5-point rating scale ranged from 1 = "Far below the acceptable level of proficiency" to 5 =

"Far exceeded the acceptable level of proficiency."

Task Proficiency Ratings. Prior to WTPT administration, airmen used a 5-point scale (1 = "Never meets acceptable level of proficiency" to 5 = "Always exceeds acceptable level of proficiency") to rate their own proficiency on AFS 426x2 tasks, including those they would perform during the Walk-Through test. Comparable supervisory ratings were also obtained prior to WTPT administration.

Experience Measures

Job Experience. Several job experience measures were collected: (a) Total Active Federal Military Service (TAFMS); (b) months in present unit; (c) months assigned to an engine type (J-57, J-79, or TF-33); (d) months of shop experience; and (e) months of flightline experience. Since these indices were highly correlated (median $r = .635$), a job experience (JOBEXP) composite score was computed for each airman as a simple arithmetic average of the five job experience measures.

Task Experience. Two measures of task experience were collected. Task Experience Ratings (TERs) were 7-point self-ratings (1 = "No Experience" to 7 = "A Very Great Amount") of relative experience on tasks performed by AFS 426x2 incumbents, including the WTPT tasks.

Number of times performed (NTP) was a self-report estimate of the number of times each WTPT task had been previously performed (coded 0 to 999). The distribution for NTP was markedly bimodal, and its correlation with TER ($r = .32$) was lower than expected. NTP scores were transformed to alleviate the severe bimodality. Transformed and original NTP scale values were: 1 = 0 times performed; 2 = 1-9 times performed; 3 = 10-19; 4 = 20-50; 5 = 51-100; 6 = 101-800; and 7 = 801-999. This transformation left the relationship between the transformed NTP and the original NTP reasonably intact ($r = .80$) and increased the correlation with TER ($r = .55$). TER and the transformed NTP scores were then averaged to form a task experience (TASKEXP) composite.

Task Difficulty

The 25-point Benchmark Task Learning Difficulty Indices (LDIs) described by Burtch et al. (1982) were used to index WTPT task difficulties.

Aptitude

Each airman's Mechanical aptitude index (MEC-AI) obtained from the ASVAB battery was used to indicate task-relevant aptitude.

Research Data Base

Task performance and task experience measures were recorded for each i th airman ($i \rightarrow N = 255$) on the j th task ($j \rightarrow J_i = 15$ for each airman) attempted in the WTPT. This yielded 3,825 (255

participants times 15 WTPT tasks) unique measures of individuals' task performance and task experience. LDIs varied appropriately across tasks and were constant for all n_j performers of the j th task. MEC-AIs and JOBEXP measures varied appropriately across each of the N airmen and were constant for each i th participant across all WTPT tasks attempted.

Since inferences from this research were to be drawn to the population of first-term airmen who meet or exceed minimal Air Force-wide enlistment standards, data records were excluded from analysis if: (a) an airman's ASVAB General-AI score was less than 30, (b) an airman's reported TAFMS was longer than 60 months, or (c) an airman's reported Months on Engine was over 50 months. Data records were also excluded if there were missing data.

Analyses

Hierarchical moderated regression (e.g., Arnold, 1982, 1984; Ward & Jennings, 1973) was the primary analytic tool used to test hypotheses H1 through H7. Main effect hypotheses were evaluated by conventional significance tests of parameter estimates in multiple linear regression models that contained appropriate aptitude, task difficulty, and experience predictors. Two-way interaction hypotheses were tested by comparing (a) the R^2 obtained from a regression model that included linear terms and a cross-product between variables in the interaction hypothesis to (b) the R^2 obtained from a regression model that included only linear terms (Arnold, 1982; Cohen & Cohen, 1975). The three-way interaction hypothesis (H7) was similarly evaluated by comparing (a) the R^2 obtained from a regression model that included linear terms, all two-way cross-product terms, and the three-way cross-product to (b) the R^2 obtained from a regression model that included only linear and two-way cross-product terms. Significant increments in R^2 due to inclusion of cross-product terms indicated the presence of a statistical interaction. The form of significant interactions was then explored in subgroup regression analyses (Arnold, 1982).

Dummy-coded task (situational) variables were also created and used with MEC-AIs, experience, and performance measures to test for homogeneity of regression across WTPT tasks. Dummy-coded task and person main effects also provided baselines to assess relative proportions of predictable variance in task performance measures attributable to task learning difficulty, aptitude, and job experience.

IV. RESULTS

Table 1 shows descriptive statistics for the study variables. All were within anticipated ranges. Table 2 shows the intercorrelations among study variables.

Table 1. Study Variables' Descriptive Statistics

	Scale range	Mean	SD	^b N of cases (possible)
<u>Performance Measures:</u>				
1. WTPT Scores	0 -10	7.34	2.37	3255(3825)
2. OPR Ratings	1 - 5	2.85	1.58	3211(3825)
3. Self Task Ratings	1 - 5	3.87	0.94	3222(3825)
4. Supervisor Task Ratings	1 - 5	3.86	1.23	3248(3825)
<u>Experience Measures:</u>				
5. Job Experience Composite	0 -48	19.36	8.80	217(255)
6. Task Experience Composite	1 - 7	3.55	1.47	3255(3825)
<u>Task Difficulty Measure:</u>				
7. Task Learning Difficulty Index	1 -25	13.91	2.18	23(23)
<u>Aptitude Measure:</u>				
8. ASVAB/MEC-AI	4-396	225.74	25.98	217(255)

^aStandard deviation.

^bNumber of valid cases (of total possible). N of cases vary due to level of analysis and missing data.

Table 2. Intercorrelations Among Study Variables

	1	2	3	4	5	6	7	8
1. WTPT Scores	1.00							
2. OPR Ratings	.64	1.00						
3. Self Task Ratings	.17	.07	1.00					
4. Supervisor Task Ratings	.16	.10	.26	1.00				
5. Job Experience Composite	.07	.02	.22	.18	1.00			
6. Task Experience Composite	.20	.08	.54	.23	.26	1.00		
7. Task LDIs	-.26	-.02	-.22	-.15	.01	-.24	1.00	
8. ASVAB MEC-AI	.05	.05	.06	.06	-.26	.01	-.01	1.00

Main Effects

Hypotheses H1, H2, H4a and H4b all concerned main effects, and all were supported (see Table 3). Task learning difficulty was the strongest predictor of the WTPT scores and, as expected, TASKEXP was a better predictor of WTPT scores than was JOBEXP. MEC-AI was a significant predictor of all dependent variables, but effects were small.

Only MEC-AI was a consistent predictor of the OPR rating. This suggests that WTPT administrators (a) may have been "leveling" their proficiency ratings for perceived differences in task difficulty and airman experience, (b) differed from one another in their implicitly assumed proficiency standards, or (c) may have been considering subtleties in performance not assessed by the dichotomous WTPT step scoring procedure.

Patterns of main effects predicting self and supervisory ratings were more similar to those relating to the WTPT scores than to the OPRs. This suggests that supervisory and self task ratings converged better with WTPT scores as comparable indicators of task performance than did OPRs (Cook & Campbell, 1979). However, low correlations between task ratings and other criteria suggested otherwise (see Table 2). WTPT scores, self and supervisor task ratings may instead represent assessments of distinct aspects of the total criterion space.

By some standards, the proportion of variance in task performance scores accounted for by the main effects was small. Golding (1975) and Abelson (1985), however, have argued against an unquestioning "variance-accounted-for" standard for judging the importance of research findings. Still, we asked: What proportion of predictable task performance score variance was accounted for by the study's variables?

To approximate an answer, the total variance in WTPT scores attributable to (unspecified) differences in situations (tasks) was estimated by creating a dummy-coded variable for all but one of the WTPT tasks (to keep the implied design matrix nonsingular). WTPT scores were regressed on the dummy-coded task variables with $R^2 = .2462$ ($F(22, 3232) = 47.99$, $p < .01$). A ratio of (a) the squared correlation between LDI and WTPT scores, and (b) the squared multiple correlation from the regression of the WTPT scores on the dummy-coded task variables ($.0567/.2462 = .23$), suggested that 23% of the variance in WTPT scores that was attributable to (unspecified) differences in tasks was attributable to differences in the tasks' learning difficulties (see James, Demaree, & Hater, 1980 for a similar approach). Tasks were deliberately sampled over a range of difficulties, so this percentage might be attributed to a successful experimental manipulation. However, similarly calculated ratios for self ($.0229/.0528 = .43$) and supervisory ($.0522/.1246 = .42$) task proficiency ratings also implied that task difficulty has a significant impact upon task performance.

We also asked: What proportion of the variance in WTPT scores that is predictable by (unspecified) interindividual differences is attributable to individual differences in aptitude and job experience? WTPT scores were regressed on dummy-coded

Table 3. Hierarchical Regression Analysis Results - Main Effects

Dependent Variable	WTPT scores	OPR ratings	Self task ratings	Supervisor task ratings
<u>Predictors:</u>				
1. ASVAB MEC-AI	.081** ^b	.057**	.115**	.120**
2. Task LDIs	-.239**	-.016	-.231**	-.153**
3. Job Experience Composite	.088**	.030	.217**	.213**
1. ASVAB MEC-AI	.056**	.049**	.055**	.061**
2. Task LDIs	-.203**	.004	-.096**	-.102**
3. Task Experience Composite	.140**	.080**	.513**	.193**

^aMain effects including Job (Task) Experience composite are shown in the upper (lower) half of the Table.

^bOrdinary least squares standardized partial regression parameter estimates (beta weights).

**₂ < .01.

person variables with $R^2 = .2244$ ($F(214,3010) = 4.07$, $p < .01$). The squared correlations between WTPT scores and MEC-AI (.00363) and JOBEXP (.00393), and the squared multiple correlation from the linear regression of WTPT on MEC-AI and JOBEXP (.01043), were computed to index the proportions of predictable WTPT variance attributable to measured individual differences. Ratios similar to those computed in analysis of between-task variance suggested that only 1.6% (.00363/.2244) of the total variance accounted for by interindividual differences was attributable to aptitude (MEC-AI), 1.8% (.00393/.2244) to job experience and 4.6% (.01043/.2244) to the combined influence of aptitude and job experience.

Similar ratios were computed for self and supervisory task ratings. Of the total variance in the self ratings accounted for by (unspecified) interindividual differences, only 1% (.0036/.3763) was attributable to aptitude (MEC-AI) and 8.9% (.0336/.3763) to job experience. For the supervisory ratings, these percentages were 0.8% (.0042/.5209) for MEC-AI and 6.2% (.0323/.5209) for job experience.

Summary. Main effects analyses implied that aptitude, experience, and task learning difficulty were significant predictors of task performance. Patterns of WTPT prediction parameter estimates were more similar to those associated with self and supervisory ratings than to the WTPT administrator OPRs. Task learning difficulty appeared to account for a sizeable proportion of predictable inter-task variance in performance measures. Aptitude and job experience measures, however, accounted for relatively little of the predictable interindividual variance in task performance measures.

Interactions

Hypothesis H7 predicted a three-way interaction between experience, aptitude, and task difficulty in predicting task performance. The three-way cross-product term was highly correlated with linear and two-way cross-product terms and accounted for essentially no additional variance in dependent variables beyond that accounted for by the lower-order effects. H7 was regarded as disconfirmed.

Tables 4 and 5 show hierarchical moderated regression tests of the two-way interaction hypotheses (H3, H5, and H6). Hypothesis H3 predicted an interaction between aptitude and task difficulty in predicting task performance, and received no support. The MEC-AI x LDI cross-product did not add significantly to the prediction of any dependent variable beyond prediction from main effects.

Hypothesis H6 predicted an interaction between experience and task learning difficulty in predicting task performance. This hypothesis received only marginal support. Significant interaction effects between LDI and TASKEXP were found only in the prediction of self and supervisor task ratings (see Table 5). Table 6 presents subgroup regression analyses that illustrate these interactions.

Table 4. Hierarchical Moderated Regression Results - Walk Through Measures

	Dependent variable					
	WTPT scores			OPR scores		
	<u>R²</u>	<u>F</u>	<u>df</u>	<u>R²</u>	<u>F</u>	<u>df</u>
<u>Linear Terms:</u>						
(M) ASVAB MEC-AI +						
(L) Task LDIs +						
(J) Job Experience Composite	.06726	78.14**	3,3251	.00357	9.50**	3,3207
(M) ASVAB MEC-AI +						
(L) Task LDIs +						
(T) Task Experience Composite	.07845	92.25**	3,3251	.00870	23.18**	3,3207
	<u>ΔR²</u>	<u>F</u>	<u>df</u>	<u>ΔR²</u>	<u>F</u>	<u>df</u>
<u>Cross-Product Terms:</u>						
M x L	.00056	1.95	1,3250	.00000	.00	1,3206
M x J	.00212	7.40**	1,3250	.00300	9.68**	1,3206
L x J	.00080	2.79	1,3250	.00002	0.06	1,3206
M x L	.00059	2.08	1,3250	.00000	.00	1,3206
M x T	.00128	4.52*	1,3250	.00184	5.96*	1,3206
L x T	.00071	2.51	1,3250	.00002	0.06	1,3206

*p < .05; **p < .01.

Table 5. Hierarchical Moderated Regression Results - Self and Supervisory Task Performance Ratings

	Dependent variable					
	Self ratings			Supervisory ratings		
	R^2	F	df	R^2	F	df
<u>Linear Terms:</u>						
(M) ASVAB MEC-AI +						
(L) Task LDis +						
(J) Job Experience Composite	.09944	118.45**	3,3218	.06920	80.39**	3,3244
(M) ASBAB MEC-AI +						
(L) Task LDis +						
(T) Task Experience Composite	.30187	463.82**	3,3218	.06194	71.94**	3,3244
	ΔR^2	F	df	ΔR^2	F	df
<u>Interaction Terms:</u>						
M x L	.00003	0.11	1,3217	.00000	.00	1,3243
M x J	.00122	4.36**	1,3217	.00570	19.99**	1,3243
L x J	.00037	1.32	1,3217	.00016	0.56	1,3243
M x L	.00001	0.05	1,3217	.00000	.00	1,3243
M x T	.00393	18.22**	1,3217	.00011	0.38	1,3243
L x T	.02009	95.35**	1,3217	.00702	24.46**	1,3243

**p < .01.

Table 6. Task Experience Subgroup Analysis of Relations Between Task Learning Difficulty and Self and Supervisor Task Proficiency Ratings

Variable	Low experience (<u>n</u> = 1068)				Medium experience (<u>n</u> = 1387)				High experience (<u>n</u> = 1260)			
	Mean	SD	Correlations		Mean	SD	Correlations		Mean	SD	Correlations	
			SER	SUR			SER	SUR			SER	SUR
SER ^a	3.5	1.5			4.0	0.8			4.5	0.8		
SUR	3.6	1.4	.14**		3.9	1.3	.12**		4.2	1.1	.10**	
LDI	14.4	2.2	-.17**	-.22**	14.1	2.2	-.21**	-.08**	13.3	2.0	.01	-.03

^aSER = Self Ratings, SUR = Supervisor Ratings, LDI = Learning Difficulty Index.

** $p < .01$.

Low, Medium, and High Task Experience subgroups were formed by selecting individuals' data records in which TASKEXP scores were below, within or above .5 standard deviation of the TASKEXP mean. Subgroup ns are unequal due to the negative skew of the TASKEXP variable. The general trend was a diminishing relationship between LDI and proficiency ratings at higher levels of task experience (correlations, rather than unstandardized regression parameter estimates are shown for interpretive ease, Kerlinger & Pedhazur, 1973). This trend may, in part, be attributable to a ceiling effect: Proficiency rating means tended toward the maximum score of 5, and rating variances were more restricted at higher experience levels. That is, at higher experience levels, airmen may become similarly proficient at both the easier and the more difficult tasks.

Hypothesis H5 predicted an interaction between aptitude and experience in predicting task performance. This hypothesis was consistently supported by small, but significant increments in variance explained in task performance measures by aptitude x experience cross-product terms, above and beyond main effects (see Tables 4 and 5). The subgroup regression analysis in Table 7 illustrates the typical interaction pattern.

Low, Medium, and High Experience subgroups were formed by selecting individuals whose JOBEXP scores were below, within, or above .5 standard deviation of the JOBEXP mean. The predictability of task performance from aptitude scores decreased among more experienced airmen. This interaction was not attributable to (a) a ceiling effect, since mean performance scores did not approach the maximum score of 10; (b) differential range restriction, since standard deviations were quite similar across subgroups; or (c) performance becoming less predictable over time, since non-significant experience x task difficulty interactions implied that prediction of task performance from LDI is constant over various levels of task and job experience. Rather, the interaction suggests that (a) proficiency increases slightly with experience, and (b) aptitude is a better predictor of proficiency earlier, rather than later, in an airman's first term of enlistment.

Predicted Aptitude Requirements

A final research question concerned the feasibility of establishing differential aptitude requirements as a function of situational (task) demands.

Results in Tables 4 and 5 show that, in general, the prediction of task proficiency from either experience or aptitude is homogeneous across tasks of various learning difficulties. Results in Table 8 reinforce this conclusion. Model I in Table 8 is the regression of WTPT task performance on dummy-coded variables representing the WTPT tasks. Model II adds linear aptitude and experience effects to Model I. Models III through VII include cross-products between the task, aptitude, and experience variables. Comparisons between Models II and I, and between Models V and II, corroborate results in Tables 4 and 5: Significant predictors of WTPT task performance are task differences, aptitude, job experience, and an aptitude x

Table 7. Subgroup Analysis of Aptitude-Performance Relations by Job Experience Level

Variable	Low experience (<u>n</u> = 1254)				Medium experience (<u>n</u> = 1029)				High experience (<u>n</u> = 917)			
	Mean	SD	Correlations		Mean	SD	Correlations		Mean	SD	Correlations	
			WTPT	OPR			WTPT	OPR			WTPT	OPR
WTPT	7.2	2.5			7.3	2.3			7.6	2.3		
OPR	2.8	1.6	.65**		2.8	1.6	.60**		2.9	1.5	.68**	
MEC-AI	229.6	25.1	.11**	.12**	228.6	22.0	.07*	.01	216.7	29.2	.02	.02

* $p < .05$; ** $p < .01$.

Table 8. Hierarchical Moderated Regression of WTPT Scores on Job Experience, MEC-AI and Dummy-Coded Task Variables

Model	Predictor(s)	R ²	df	F
I.	Task Variables (T)	.24625	22,3232	47.99**
II.	Task Variables (T) + MEC-AI (M) + JOBEXP (J)	.25636	24,3230	46.40**
III.	T + M + J + TxM	.25939	46,3208	24.42**
IV.	T + M + J + TxJ	.26331	46,3208	24.93**
V.	T + M + J + MxJ	.25872	25,3229	45.08**
VI.	T + M + J + TxM + TxJ + MxJ	.26906	69,3185	16.99**
VII.	T + M + J + TxM + TxJ + MxJ + TxJxM	.27423	91,3163	13.13**

Model Comparisons	ΔR^2	df	F
II vs. I	.01011	2,3230	21.96**
III vs. II	.00302	22,3208	0.59
IV vs. II	.00695	22,3208	1.38
V vs. II	.00236	1,3229	10.28**
VI vs. V	.01034	44,3185	1.02
VII vs. VI	.00517	22,3163	1.02

**p < .01.

experience interaction. Nonsignificant interaction effects between task variables and other regression terms indicated homogeneous Model V regressions across tasks.

One approach to linking aptitude requirements to task (situational) demands is illustrated by selecting unstandardized parameter estimates from the regression of WTPT scores on MEC-AI, task LDIs, and JOBEXP:

$$\text{WTPT} = 8.81 + .007 \cdot \text{MEC-AI} + .024 \cdot \text{JOBEXP} - .259 \cdot \text{LDI} \quad (1)$$

WTPT was fixed arbitrarily at the grand mean (7.34). MEC-AI cutoff scores implied by various task LDIs were then examined at three levels of JOBEXP (the mean and plus/minus one standard deviation). With WTPT and JOBEXP values thus fixed, implied MEC-AIs were computed from Equation 1 as a function LDI values. Implied MEC-AIs were converted to percentile equivalents, and those that were beyond the upper or lower ranges were set to limiting values (i.e., the 1st and 99th percentiles). Figure 1 shows that given a desired level of task proficiency (in this case, the mean task proficiency level), predicted MEC-AI requirements are a function of: (a) task difficulty level, and (b) amount of time allowed to attain the desired level of proficiency.

V. CONCLUSIONS AND DISCUSSION

1. Person and situational variables predict task performance. Findings indicated that (a) task-relevant aptitude (e.g., ASVAB MEC-AI), (b) job experience, (c) task experience, and (d) task learning difficulty are valid predictors of Jet Engine Mechanic (AFS 426x2) task proficiency. Although there is abundant evidence that aptitudes are consistent predictors of job performance (e.g., Hunter & Hunter, 1984; Pearlman, et al., 1980; Schmidt, Hunter & Caplan, 1981; Schmidt, Hunter & Pearlman, 1981), the present findings suggest that the prediction of performance may be enhanced by including additional person and situational predictors. Future research should determine the usefulness of alternative person variables (e.g., prior work and educational experience) and situational variables (e.g., situational constraints, O'Connor et al., 1984) in enhancing the prediction of airman proficiency.

2. Aptitude and on-the-job experience interact in predicting task proficiency. Findings indicated that the predictability of task proficiency from task-relevant aptitude diminished among progressively more experienced airmen. This suggests that aptitude plays a significant role in determining proficiency early in an airman's first term of enlistment, but that later on, other factors (e.g., on-the-job training) overshadow aptitude contributions to proficiency.

Future research should attempt refinements of the definition and measurement of job and task experience. "Experience" connotes acquisition of job-related skills and abilities that, over time, affect proficiency. But just as chronological age is a defi-

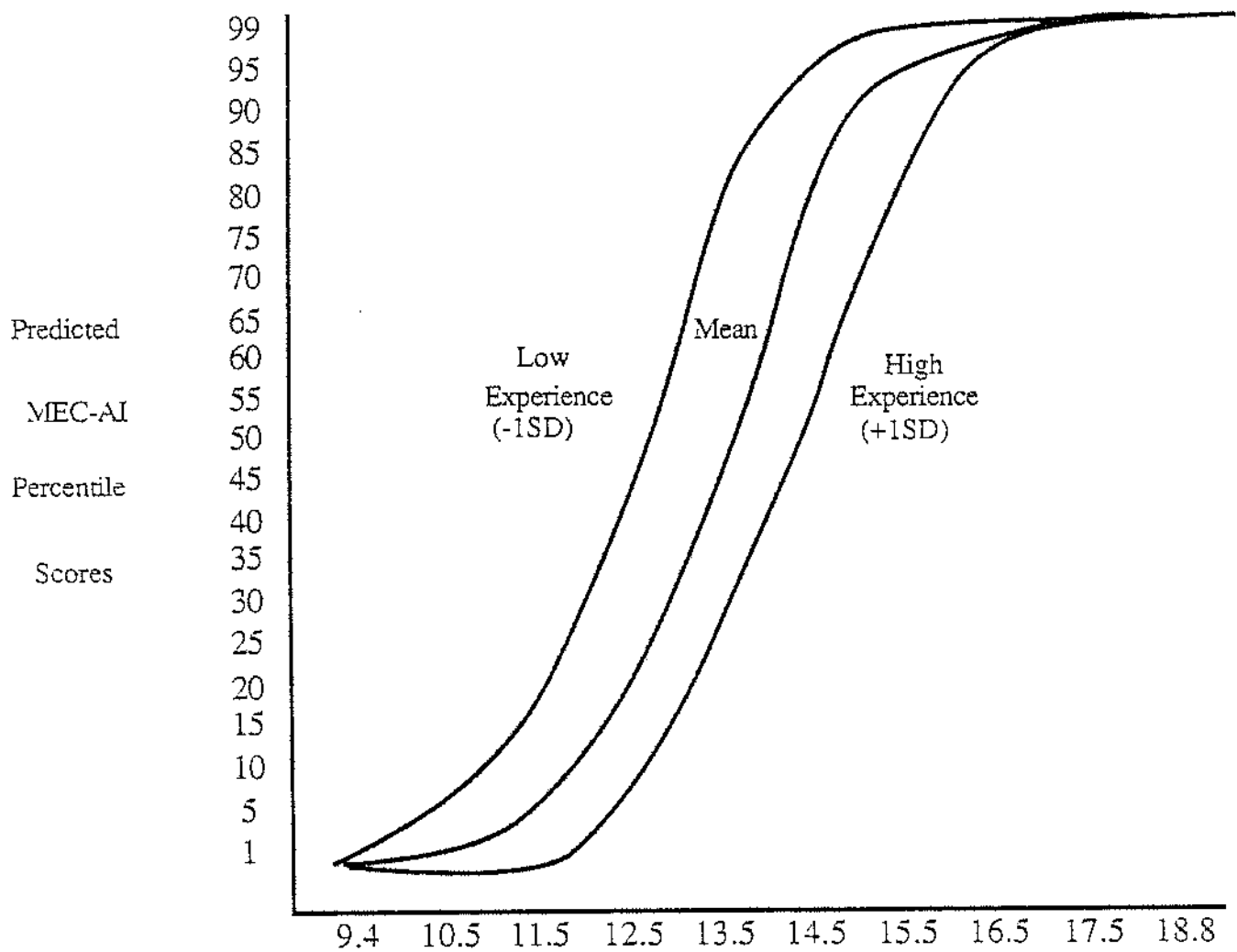


Figure 1. Aptitude cutoff scores implied for tasks of varying learning difficulty at three levels of experience and constant target performance level.

cient indicator of aging effects (Minton & Schneider, 1985), so is tenure a deficient indicator of experience. Other surrogate experience measures such as the self experience ratings and the "number of times performed" measure used in this study are more direct assessments of experience, but may still be deficient indicators of the experience construct. A definition of the experience construct that reflects meanings usually accorded it is needed, as are more comprehensive measures of the construct.

Longitudinal research should also be conducted to determine the differential contributions of aptitude and experience to performance over time. For many research questions, longitudinal studies merely afford a comparison between a static correlation and prediction over some time interval. However, experience effects on performance imply changes over time, which, in cross-sectional studies, can be misattributed to maturation, nonrandom selection, or attrition effects. In general, longitudinal designs do not bolster confidence in causal inferences from nonexperimental data (Cook & Campbell, 1979; Rogosa, 1980). However, appropriate multivariable, multiwave designs such as cross-sectional time series designs permit statistical (e.g., pseudo-generalized least squares) estimates for (a) bias in parameter estimates due to unmeasured relevant causes of performance which, when corrected, permit (b) unbiased estimates of causal effects leading to job performance.

The problem of diminishing predictability of performance from aptitudes should also be studied in the contexts of: (a) indirect effects of aptitude on later task performance, (b) temporally proximal aptitude and skill determinants of performance, and (c) non-ability determinants of performance beyond the first few years of enlistment (e.g., motivation, situational constraints, leader facilitation and support, commitment to performance).

3. Alternative task proficiency measures as defined in this investigation did not capture common aspects of the total criterion space. Prediction results for WTPT scores and self and supervisory task proficiency ratings were quite similar. One piece of evidence for convergent validity of measures is that they do share similar predictors (Cook & Campbell, 1979). In this sense, self and supervisory task ratings appeared to converge better with WTPT scores than did OAP ratings. However, low correlations between WTPT scores and task ratings indicated a lack of complete convergence. Although WTPT scores and task ratings may be similarly predicted from aptitude scores, they may also assess distinct and different aspects of the total criterion space.

Future research should attempt to disentangle measurement source and criterion true score effects in proficiency measures. Kenny and Berman (1980), Lance and Lautenschlager (1987), and Widaman (1985) discussed how this might be accomplished using multiple assessments of proficiency, each obtained from multiple, distinct measurement sources. Success in this area could lead to technologies for the statistical control of measurement method bias (Lance & Woehr, 1986; Wherry & Bartlett, 1982) and estimation of latent true proficiency scores (Hulin, Drasgow, & Parsons, 1983; Kenny & Berman, 1980).

4. Task experience and learning difficulty may interact in predicting task proficiency ratings. Findings indicated that the prediction of task proficiency ratings from tasks' LDI's diminished with increased task experience. These findings may reflect on-the-job-training contributions to proficiency on easier and, at higher experience levels, more difficult tasks.

However, similar effects were not observed for the prediction of WTPT or OPR proficiency measures. Self and supervisor ratings are more likely to be influenced by judgments of day-to-day performance than are the Walk Through measures. Thus, interactive effects between task experience and difficulty may be more apparent on proficiency measures that may also be influenced by motivation and interpersonal relations.

Interactive effects between task experience and difficulty in predicting task proficiency ratings may also represent a spurious relation resulting from raters' implicit covariance theories (Feldman, 1981). The diminishing predictability of proficiency ratings from task difficulty measures at higher experience levels may have resulted merely from incumbents' and supervisors' implicit beliefs that (a) less experienced airmen are likely to have mastered easier, but not more difficult, tasks; whereas (b) more experienced airmen are likely to have attained proficiency on all job-relevant tasks.

These findings and alternative interpretations reinforce the need for further research on defining the experience construct and dimensional aspects of the total criterion space. They also point to the need for more comprehensive study of the contexts in which proficiency is developed and observed. Clearly, the influences of formal and informal training on proficiency and day-to-day performance should be explicated in the context of aptitude, attitudinal, and situational determinants. The roles of performance expectations in influencing actual proficiency (e.g., Eden & Shani, 1982) and judgments about proficiency (e.g., Kozlowski & Hults, 1986) should also be examined.

5. Predicted aptitude requirements may be derived from analysis of situational demands. A prototype methodology was demonstrated for linking aptitude requirements to task learning difficulty. The methodology requires measures of: (a) performance, (b) aptitude, and (c) salient differences between situations (tasks, occupations). Performance must also be significantly related to (a) aptitude, and (b) the salient situational variable. Other variables related to performance (e.g., experience) may further define the link between situational characteristics and implied aptitude requirements.

Future cross-specialty research is needed to determine the appropriateness of this or other approaches for linking aptitude requirements to situational characteristics. Attempts to link enlistment standards to situational demands (e.g., Occupational Learning Difficulty) must be based on established relations between performance and aptitude predictors at the individual level, and macro, specialty-level difficulty indices. Accomplishing this goal will require: (a) development of the appropriate statistical rationale for relating measures taken at different conceptual levels of aggregation; (b) collection of aptitude, performance, and job/task difficulty scores on incum-

bents and tasks across several specialties; (c) common proficiency standards for airmen in different specialties; and (d) a demonstrated cross-specialty relationship between proficiency and specialty-level difficulty indices.

REFERENCES

- Abelson, R.P. (1985). A variance explanation paradox: When a little is a lot. Psychological Bulletin, 97, 129-133.
- Arnold, H.J. (1982). Moderator variables: A clarification of conceptual, analytic, and psychometric issues. Organizational Behavior and Human Performance, 29, 143-174.
- Arnold, H.J. (1984). Testing moderator variable hypotheses: A reply to Stone and Hollenbeck. Organizational Behavior and Human Performance, 34, 214-224.
- Bowers, K.S. (1973). Situationism in psychology: An analysis and a critique. Psychological Review, 80, 307-333.
- Brown, C. (1982). Estimating the determinants of employee performance. Journal of Human Resources, 17, 178-194.
- Burtch, L.D., Lipscomb, M.S., & Wissman, D.J. (1982, January). Aptitude requirements based on task difficulty: Methodology for evaluation (AFHRL-TR-81-34, AD-A110 568). Brooks AFB, TX: Air Force Human Resources Laboratory, Manpower and Personnel Division.
- Casali, J.G., & Wierwille, W.W. (1983). A comparison of rating scale, secondary-task, physiological, and primary-task workload estimation techniques in a simulated flight task emphasizing communications load. Human Factors, 25, 623-641.
- Cobb, B.B. (1968). Relations among chronological age, length of experience, and job performance ratings of air traffic control specialists. Aerospace Medicine, 39, 119-124.
- Cohen, J., & Cohen, P. (1975). Applied multiple regression/correlation analysis for the behavioral sciences. New York: Wiley.
- Cook, T.D., & Campbell, D.T. (1979). Quasi-experimentation: Design & analysis issues for field settings. Boston, MA: Houghton Mifflin.
- Eden, D., & Shani, A.B. (1982). Pygmalion goes to boot camp: Expectancy, leadership, and trainee performance. Journal of Applied Psychology, 67, 194-199.
- Ekehammer, B. (1974). Interactionism in personality from a historical perspective. Psychological Bulletin, 81, 1026-1048.
- Endler, N.S., & Magnusson, D. (1976). Toward an interactional psychology of personality. Psychological Bulletin, 83, 956-974.

- Epstein, S., & O'Brien, E.J. (1985). The person-situation debate in historical and current perspective. Psychological Bulletin, 98, 513-537.
- Feldman, J.M. (1981). Beyond attribution theory: Cognitive processes in performance appraisal. Journal of Applied Psychology, 66, 127-148.
- Fishbein, M., & Ajzen, I. (1974). Attitudes towards objects as predictors of single and multiple behavioral criteria. Psychological Review, 81, 59-74.
- Fleishman, E.A. (1978). Relating individual differences to the dimensions of human tasks. Ergonomics, 21, 1007-1019.
- Fugill, J.W.K. (1973, October). Task difficulty and task aptitude benchmark scales for the administrative and general career fields (AFHRL-TR-73-13, AD-771677). Brooks AFB, TX: Personnel Research Division, Air Force Human Resources Laboratory.
- Gininger, S., Dispenzieri, A., & Eisenberg, J. (1983). Age, experience and performance on speed and skill jobs in an applied setting. Journal of Applied Psychology, 68, 469-475.
- Golding, S.L. (1975). Flies in the ointment: Methodological problems in the analysis of the percentage of variance due to persons and situations. Psychological Bulletin, 82, 278-288.
- Hedge, J.W. (1984, August). The methodology of walk-through performance testing. Paper presented at the meeting of the American Psychological Association, Toronto, Ontario, Canada.
- Hedge, J.W. & Teachout, M.S. (1986). Job performance measurement: A systematic program of research and development (AFHRL-TP-86-37, AD-A174 175). Brooks AFB, TX: Training Systems Division, Air Force Human Resources Laboratory.
- Horowitz, S.A., & Sherman, A. (1980). A direct measure of the relationships between human capital and productivity. Journal of Human Resources, 15, 67-76.
- Hulin, C.L., Drasgow, F., & Parsons, C.K. (1983). Item response theory. Homewood, IL: Dow Jones-Irwin.
- Hunter, J.E., & Hunter, R.F. (1984). Validity and utility of alternative predictors of job performance. Psychological Bulletin, 96, 72-98.
- James, L.R., Demaree, R.G. & Hater, J.J. (1980). A statistical rationale for relating situational variables and individual differences. Organizational Behavior and Human Performance,

- James, L.R., & White, J.F. III (1983). Cross-situational specificity in managers' perceptions of subordinate performance, attributions, and leader behavior. Personnel Psychology, 36, 809-855.
- Katz, R. (1978). The influence of job longevity on employee reactions to task characteristics. Human Relations, 31, 703-725.
- Kavanagh, M.J., Borman, W.C., Hedge, J.W., & Gould, R.B. (1986, February). Job performance measurement classification scheme for validation research in the military. (AFHRL-TP-85-51 AD-A164 837). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.
- Kenny, D.A., & Berman, J.S. (1980). Statistical approaches to the correction of correlational bias. Psychological Bulletin, 88, 288-295.
- Kerlinger, F.N., & Pedhazur, E.J. (1973). Multiple regression in behavioral research. New York: Holt, Rinehart, and Winston.
- Komaki, J.L., Zlotnick, S., & Jensen, M. (1986). Development of an operant-based taxonomy and observational index of supervisory behavior. Journal of Applied Psychology, 71, 260-269.
- Kozlowski, S.W.J., & Hults, B.M. (1986). Joint moderation of the relation between task complexity and job performance for engineers. Journal of Applied Psychology, 71, 196-202.
- Lance, C.E., & Lautenschlager, G. (1987). Applications of confirmatory factor analysis to performance rating data. Manuscript submitted for publication.
- Lance, C.E., & Woehr, D.J. (1986). Statistical control of halo: A clarification from two cognitive models of the performance appraisal process. Journal of Applied Psychology, 71, 679-685.
- Locke, E.A., Shaw, K.N., Saari, L.M., & Latham, G.P. (1981). Goal setting and task performance: 1969-1980. Psychological Bulletin, 90, 125-152.
- Loher, B.T., Noe, R.A., Moeller, N.L., & Fitzgerald, M.P. (1985). A meta-analysis of the relation of job characteristics to job satisfaction. Journal of Applied Psychology, 70, 280-289.
- Maier, M.H., & Hiatt, C.M. (1985). On the content and measurement of validity of hands-on job performance tests (CRM 85-79). Alexandria, VA: Marine Corps Operations Analysis Group, Center for Naval Analyses.

- Mathews, J.J., & Cobb, B.B. (1974). Relationships between age, ATC experience, and job ratings of terminal air traffic controllers. Aerospace Medicine, 15, 186-216.
- McGrath, J.E. (1976). Stress and behavior in organizations. In M.D. Dunnette (Ed.), Handbook of Industrial/Organizational Psychology. Chicago, IL: Rand-McNally.
- Medoff, J.L., & Abraham, K.G. (1980). Experience, performance, and earnings. The Quarterly Journal of Economics, 95, 703-736.
- Medoff, J.L., & Abraham, K.G. (1981). Are those paid more really more productive? The case of experience. The Journal of Human Resources, 16, 186-216.
- Minton, H.L., & Schneider, F.W. (1985). Differential Psychology. Prospect Heights, IL: Waveland.
- Moray, N. (1982). Subjective mental workload. Human Factors, 24, 25-40.
- Mullins, C.J., Earles, J.A., & Ree, M. (1981, July). Weighting of aptitude components based on differences in technical school difficulty (AFHRL-TR-81-19, AD-A102 045). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.
- O'Connor, E.J., Peters, L.H., Eulberg, J.R., & Watson, T.W. (1984, November). Situational constraints in the Air Force: Identification, measurement, and impact on work outcomes (AFHRL-TP-84-10, AD-A149316). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.
- Oldham, G.R., Hackman, J.R., & Pearce, J.L. (1976). Conditions under which employees respond positively to enriched work. Journal of Applied Psychology, 61, 395-403.
- Pearlman, K., Schmidt, F.L., & Hunter, J.E. (1980). Validity generalization results for tests used to predict job proficiency and training success in clerical occupations. Journal of Applied Psychology, 65, 373-406.
- Rhodes, S.R. (1983). Age-related differences in work attitudes and behavior: A review and conceptual analysis. Psychological Bulletin, 93, 328-367.
- Rogosa, D. (1980). A critique of cross-lagged correlation. Psychological Bulletin, 88, 245-254.
- Rothe, H.F. (1949). The relation of merit ratings to length of service. Personnel Psychology, 2, 237-242.

- Schmidt, F.L., Hunter, J.E., & Caplan, J.R. (1981). Validity generalization results for two groups in the petroleum industry. Journal of Applied Psychology, 66, 261-273.
- Schmidt, F.L., Hunter, J.E., & Pearlman, K. (1981). Task differences as moderators of aptitude test validity in selection: A red herring. Journal of Applied Psychology, 66, 166-185.
- Schneider, B. (1978). Person-situation selection: A review of some ability-situation interaction research. Personnel Psychology, 31, 281-297.
- Schwab, D.P., & Heneman, H.G. III. (1977). Effects of age and experience on productivity. Industrial Gerontology, 4, 113-118.
- Spiker, V.A., Harper, W.R., & Hayes, J.F. (1985). The effect of job experience on the maintenance proficiency of Army automotive mechanics. Human Factors, 27, 301-311.
- Stagner, R. (1977). On the reality and relevance of traits. Journal of General Psychology, 96, 185-207.
- Stone, E.F., & Gueutal, H.G. (1985). An empirical derivation of the dimensions along which characteristics of jobs are perceived. Academy of Management Journal, 28, 376-396.
- Terborg, J.R. (1977). Validation and extension of an individual differences model of work performance. Organizational Behavior and Human Performance, 18, 188-216.
- Terborg, J.R. (1981). Interactional psychology and research on human behavior in organizations. Academy of Management Review, 6, 569-576.
- Terborg, J.R., Richardson, P., & Pritchard, R. D. (1980). Person-situation effects in the prediction of performance: An investigation of ability, self-esteem and reward contingencies. Journal of Applied Psychology, 65, 574-583.
- Vineberg, R., & Joyner, J.N. (1983). Performance measurement in the military. In F.J. Landy, S. Zedeck, & J. Cleveland (Eds.), Performance measurement and theory. Hillsdale, NJ: Erlbaum.
- Waldman, D.A., & Avolio, B.J. (1986). A meta-analysis of age differences in job performance. Journal of Applied Psychology, 71, 33-38.
- Ward, C.J., & Jennings, E. (1973). Introduction to linear models. Englewood Cliffs, NJ: Prentice Hall.
- Weeks, J. (1984). Occupational learning difficulty: A standard for determining the order of aptitude requirement minimums

(AFHRL-SR-84-26, AD-A147 410). Brooks AFB, TX: Manpower and Personnel Division, Air Force Human Resources Laboratory.

Wherry, R.J., Sr., & Bartlett, C.J. (1982). The control of bias in ratings: A theory of rating. Personnel Psychology, 35, 521-531.

Widaman, K.F. (1985). Hierarchically nested covariance structure models for multitrait-multimethod data. Applied Psychological Measurement, 9, 1-26.

Wierwille, W.W., Rahimi, M., & Casali, J.G. (1985). Evaluation of 16 measures of mental workload using a simulated flight task emphasizing mediational activity. Human Factors, 27, 489-502.